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Communications and Electronics, Inc.

NATIONAL SERVICE TECHNICIAN'S GUIDE

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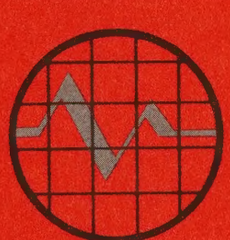
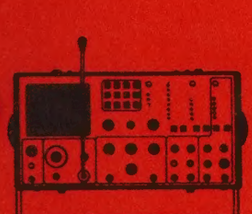
Portable Products

Servicing MX300 "Handie-Talkie" Portable Radio Options





TT-404

NATIONAL SERVICE TRAINING

PORTABLE PRODUCTS

SERVICING

MX300 "HANDIE-TALKIE"

PORTABLE RADIO OPTIONS

PREPARED BY

NATIONAL SERVICE TRAINING CENTER

PLANTATION, FLORIDA

SEPTEMBER, 1984

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NATIONAL SERVICE TRAINING

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I. INTRODUCTION

It is the purpose of this Technician Guide to provide troubleshooting techniques for the four most popular MX300 series radio additions: Time-Out Timer, Selective Call, Unit Identification and Digital Voice Protection/Data Encryption Standard.

Theory of operation will not be covered but can be found in the following publications:

Time-Out Timer, Selective Call and Unit Identification	68P81013C-70A
Digital Voice Protection/Data Encryption Standard	68P81036C-95O

To aid the technician in troubleshooting the options of this guide, a list of recommended test equipment is provided in Section II, followed by a list of Service Aids and Repair Tools in Section III. Be sure to look through these lists to insure you have all the necessary hardware or an equivalent substitute before beginning service.

It should be noted that Section IV, "Digital Voice Protection"/"Data Encryption Standard" applies to servicing synthesized MX300 series radios and not the non-synthesized version. If you have non-synthesized "Digital Voice Protection"/"Data Encryption Standard" MX300 series radios in your system, we recommend Technician's Guide TT-501, "Digital Voice Protection System". This guide is dedicated to non-synthesized MX300 series radios and includes theory of operation.

In portable radio servicing, the results that you obtain, as in any undertaking, are directly related to the effort put forth. This booklet has been produced in order to help you extend maximum effort in servicing these options of the Motorola MX300 Series Radio.

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II. TEST EQUIPMENT

The ease with which radio performance tests can be performed or a malfunction analyzed is directly related to the capabilities of the test equipment being used. (All of the servicing data included in this publication was compiled using the test equipment outlined here).

It is recommended that the equipment described here, or its equivalent, be used as a guide for the initial purchase, addition to, or replacement of existing equipment.

AC VOLTMETER - For measuring discriminator, squelch and audio stages in alignment and troubleshooting.

Hewlett Packard 400FL AC Voltmeter

BENCH POWER SUPPLY - 0 to 20 VDC, current limiting power supply, with meter range selection of both voltage and current meters.

Motorola S-1347B or S-1348B (Programmable)

CODE SYNTHESIZER - For modulating the RF signal generator with the proper "Private-Line," "Digital Private-Line," "Selective Call," or IMTS test signals.

Motorola R-1100A Code Synthesizer

DC MULTIMETER - General purpose instrument for receiver and transmitter alignment and troubleshooting.

R-1037A Digital Multimeter

OSCILLOSCOPE - General troubleshooting of audio, squelch, and various signaling options.

Motorola R-1004A Dual Trace Oscilloscope

RF MILLIVOLTMETER - For measuring RF sections of the receiver and transmitter. Must be used with a 100:1 adaptor for measurements over 3 VRF.

Motorola S-1339A RF Millivoltmeter
RTL-4040A High Voltage Probe

R-1012 DVP (Digital Voice Protection) test set provides facilities for checking the proper operation of the digital voice protection circuits of a Motorola two-way radio system.

R-1032A DES (Data Encryption Standard for Digital Voice Protection) test set provides facilities for checking the proper operation of the data encryption standard circuits of a Motorola two-way radio system.

SERVICE MONITOR - Used as an RF signal generator, IF generator, frequency meter, deviation meter, and general purpose oscilloscope.

Motorola R-2001A Communication System Analyzer

SINAD METER - Used for checking 12 dB SINAD of the receiver.

Motorola R-1013A SINAD Meter

WATTMETER - Used to measure transmitter power. Must be terminated in 50 ohms.

Motorola S-1350A Wattmeter with plug-in elements
Bird Model 6154 0-2, 0-10 watt scales.

In general, a fully functional test equipment bench position for the MX300 radio could be set up using:

1. R-2001A Communications Systems Analyzer.
2. HP 400FL AC Voltmeter (has -90 dBm sensitivity).
3. S-1339A RF Millivoltmeter.
4. S-1347B Bench Power Supply.

III. SERVICE AIDS & REPAIR TOOLS

In addition to the test equipment recommendations detailed in Section II, there are other items of specialized servicing equipment needed to properly service the options covered in this guide. The following list names and briefly describes the more important servicing items.

RTL-4124A EXTENDER BOARD (for Unit ID Option) - Plugs into the mainboard and mates with the interface board to allow easy access to test points.

RTL-4123A EXTENDER BOARD (for Unit ID Option) - Plugs into the mainboard and mates with the computer board to allow easy access to test points.

PLN-6864A STAGE MODULE (for DVP/DES Option) - Replaces the "Flex-O-Pak" module to allow the unit to be tested as a standard radio.

SKN-6028A RF ADAPTER CABLE - This cable will be used to connect test equipment; either a wattmeter or signal generator, to the RF jack on the side of the MX300 radio. This cable is part of the RTK-4021A test cable.

RTX-4005A PORTABLE RADIO TEST SET - Used in conjunction with a special test cable to plug into the Converta-Com radio connector on the side of the "MX300" radio. This test set provides access to many of the radio functions needed for performance and trouble-shooting of both transmitter and receiver sections.

RTK-4021A TEST SET CABLE - Mates with the "MX300" radio Converta-Com side connector and provides the input connection to the RTX-4005A. It also provides a male BNC connector for RF input/output connections to the RF side connector jack. (Used for all "MX300" radios, but is the only acceptable cable for 800 MHz.)

ST-1175 BATTERY BLOCK - Provides a simple means of connecting a power supply to the radio. Incorporated in the battery block are reverse polarity and over voltage protection circuits.

ST-1144/ST-1146 MODULE DESOLDERING IRON Allows convenient removal of soldered in flex circuits and modules without damaging the circuit board. Three solder reservior tips: 66-84208D36 small, 66-84208D37 medium, and 66-84208D38 large.

ST-1087 WELLER W-TCP-N SOLDERING STATION - Utilizes a closed loop temperature controlled tip system. Tips available in 700°, 800°, and 900° temperatures. Recommended tips for portable applications are:

ST-1088	1/32" conical flat 800° tip.
ST-1167	Screwdriver, 1" reach 800° tip

RSX-1002A POWER DESOLDERING SYSTEM - This tool is excellent for removing discrete components, the control flex, or module sockets from the four layer printed circuit board without damaging the board. The system is composed of a temperature controlled desoldering handpiece, a power unit which develops the vacuum to draw molten solder out of the plated holes of the board, and a regular temperature controlled soldering iron for normal soldering operation. This desoldering system is similar to the Pace desoldering system.

ST-1179 MODULE PUSH TOOL KIT - A tool that will permit easy removal of modules.

ST-1181 TUNING TOOL KIT - Used to tune up the preselector and channel elements.

ST-1180 RF JACK/PRESELECTOR SPANNER WRENCH- Aids in the removal of RF jack and preselector housing nuts.

HAND TOOLS AS FOLLOWS:

1. 3/16" Slotted Flat-Blade Screwdriver.
2. Phillips Screwdriver - No. 1 Point Size.
3. Needle Nose Pliers, ST-202.
4. Prober (Dental Pick), 66-84253C73.
5. Wire Cutters, ST-200.
6. Wire Strippers, ST-562.
7. Seizers (Hemostats), 66-93117C01.
8. Tweezers, ST-492.
9. Solvent - Pure Isopropyl Alcohol (refer to Service and Repair Note 790).
10. Solvent Brush - 1/2" trim paint brush with bristles cut to 1/2" length.

SOLDER - It is recommended that a top quality solder be used in any repair work performed on the "MX300" radio. Rosin core solder .030" or .031" in diameter and 63/37 or 60/40 tin/lead composition has proved to be the most successful. DO NOT use acid core solder.

IV. DIGITAL VOICE PROTECTION DATA ENCRYPTION STANDARD

All circuitry for digitizing and scrambling voice on synthesized MX300 series radios is mounted on one flex circuit and inserted into a single module can. The complete assembly is called the "Flex-O-Pak" module or simply "Flex-O-Pak". The "Flex-O-Pak" is NOT field serviceable and therefore no attempt should be made to interrogate the module.

The first step in troubleshooting an MX300 portable radio with voice protection is to determine if a problem exists on the main transceiver board or within the "Flex-O-Pak". To separate the two boards, one of two techniques can be used.

The first way to separate the circuitry is to re-install the jumpers at JU4, JU6 and JU7 on the transceiver board and remove the "Flex-O-Pak". (Refer to the appropriate service manual for proper jumper placement: VHF 68P81022C10; UHF 68P81022C15). With these jumpers re-installed and the "Flex-O-Pak" removed, the unit should meet all standard receiver and transmitter performance checks as listed in Technician's Guide TT-403, "Servicing MX300 'Handie-Talkie' Portable Radios".

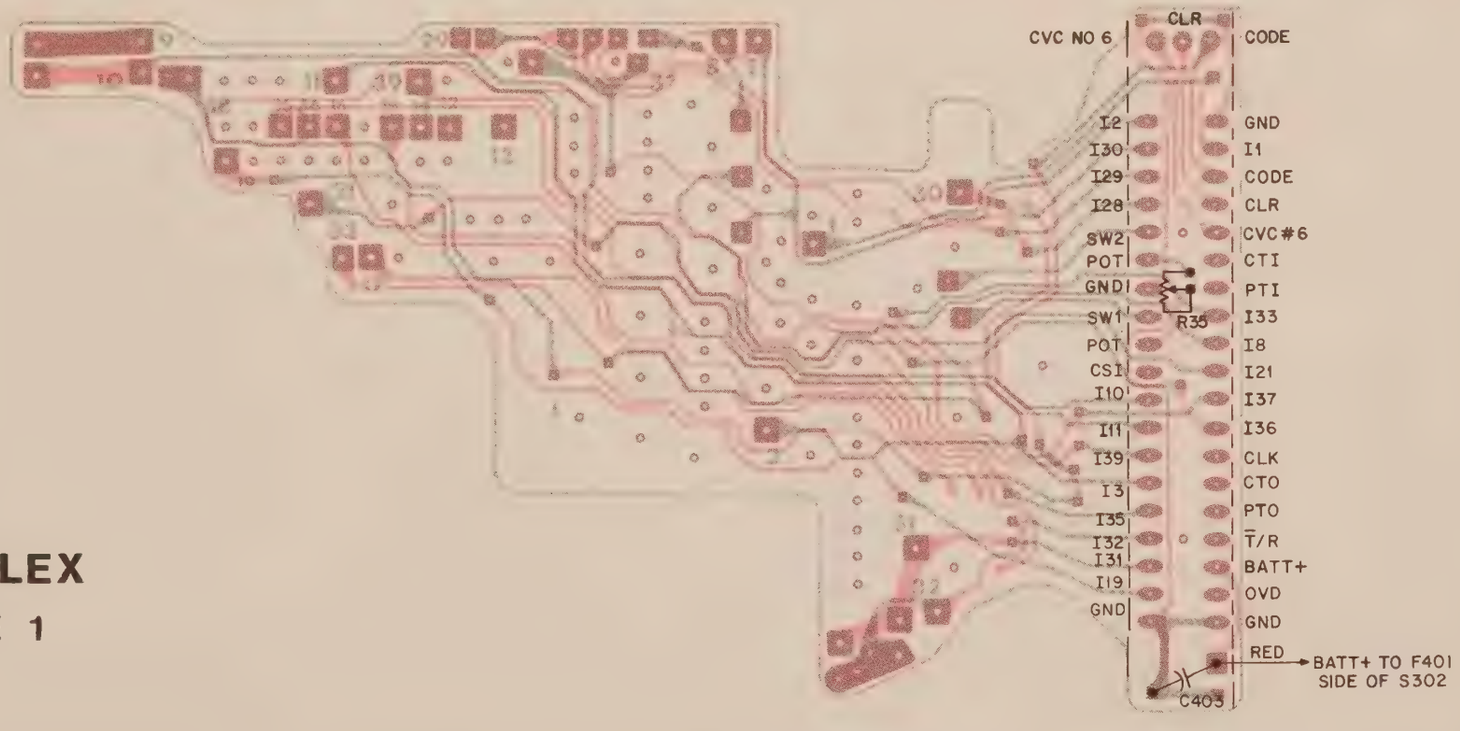
The second way to isolate the two boards from one another is to use a "STAGE• MODULE" (PLN6864A). The stage module is a "Flex-O-Pak" module but has the appropriate jumpers to bypass the digital voice protection circuitry, thus allowing the unit to operate as a standard radio. With the stage module installed in place of the "Flex-O-Pak", the unit should meet all standard receiver and transmitter performance checks.

Should the radio fail a standard performance check using the bypassing technique described above, servicing the transceiver board is indicated and Technician's Guide TT-403, "Servicing MX300 'Handie-Talkie' Portable Radios" should be consulted. The transceiver board must pass all performance checks before suspecting a bad "Flex-O-Pak".

If the radio passes the performance checks with the "Flex-O-Pak" circuitry bypassed, a new "Flex-O-Pak" should be installed and the unit checked in both clear and coded modes. Should the unit fail to operate with a known good "Flex-O-Pak" and the unit has been verified to have a good working transceiver board, the Modu-Flex should be replaced.

Shown in Table 1 on the next page are normal DC voltage readings at the interconnect point of the Modu-Flex from a working "Flex-O-Pak" module. This chart should be used to verify proper operation of the "Flex-O-Pak".

VIEWED FROM SOLDER SIDE



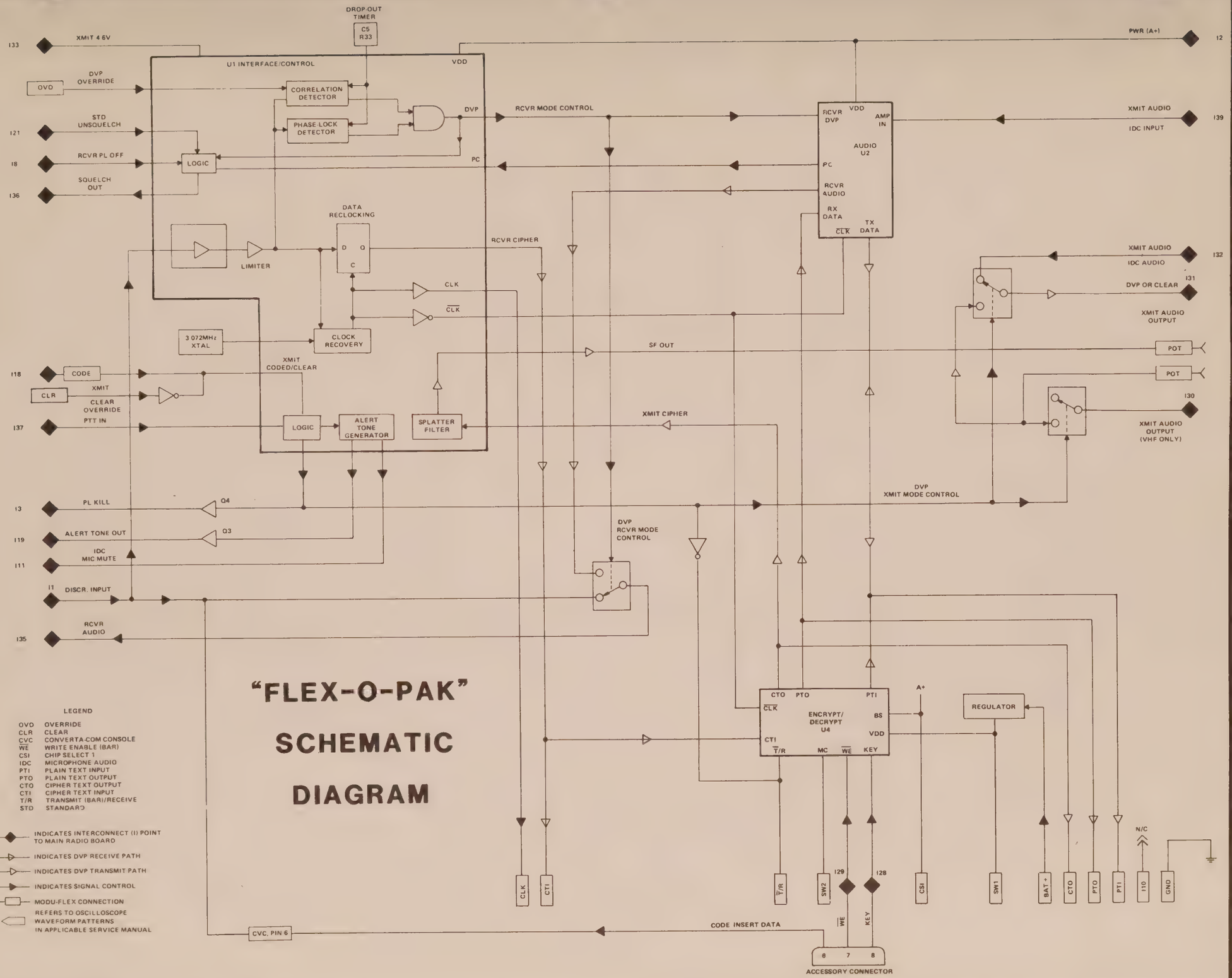
MODU-FLEX

FIGURE 1

MODU-FLEX DC READINGS

INTERCONNECT POINT	Rx	Tx	INTERCONNECT POINT	Rx	Tx
I 2	7.5	7.5	I 31	0	0.75
I 30	0	0	I 19	3.7	0
I 29	0	0	I 1	1.5	1.5
I 28	0	0	I 18	7.5	7.5
I 10	7.5	1.1	I 33	0	4.5
I 11	0	0	I 8	7.5	7.5
I 39	0	2.8	I 21	0	0
I 3	4.2	2.8	I 37	5	0.75
I 35	1.5	1.5	I 36	0	0
I 32	0	0.75			

TABLE 1


DROP-OUT TIMER
C5
R33
133
XMIT 4.6V
U1 INTERFACE/CONTROL
VDD
OVD
DVP OVERRIDE
CORRELATION DETECTOR
PHASE-LOCK DETECTOR
DVP
121
STD UNSQUELCH
18
RCVR PL OFF
LOGIC
PC
136
SQUELCH OUT
DATA RECLOCKING
D
Q
C
LIMITER
RCVR CIPHER
CLK
CLK
3.072MHz XTAL
CLOCK RECOVERY
SF OUT
118
CODE
XMIT CODED/CLEAR
CLR
XMIT
CLEAR OVERRIDE
137
PTT IN
LOGIC
ALERT TONE GENERATOR
SPLATTER FILTER
XMIT CIPHER
13
PL KILL
Q4
119
ALERT TONE OUT
Q3
111
IDC MIC MUTE
11
DISCR. INPUT
135
RCVR AUDIO
RCVR MODE CONTROL
RCVR DVP
VDD
AMP IN
AUDIO U2
PC
RCVR AUDIO
RX DATA
TX DATA
CLK
PWR (A+)
12
XMIT AUDIO
IDC INPUT
139
XMIT AUDIO
IDC AUDIO
132
DVP OR CLEAR
131
XMIT AUDIO OUTPUT
POT
POT
130
XMIT AUDIO OUTPUT (VHF ONLY)
DVP XMIT MODE CONTROL
DVP RCVR MODE CONTROL
CTO
PTO
PTI
CLK
ENCRYPT/ DECRYPT U4
BS
VDD
CTI
T/R
MC
WE
KEY
A+
REGULATOR
N/C
CLK
CTI
T/R
SW2
129
128
CSI
SW1
BAT+
CTO
PTO
PTI
110
GND
WE
KEY
CODE INSERT DATA
CVC, PIN 6
8
7
8
ACCESSORY CONNECTOR
"FLEX-O-PAK"
SCHEMATIC
DIAGRAM
LEGEND
OVD OVERRIDE
CLR CLEAR
CVC CONVERTA-COM CONSOLE
WE WRITE ENABLE (BAR)
CSI CHIP SELECT 1
IDC MICROPHONE AUDIO
PTI PLAIN TEXT INPUT
PTO PLAIN TEXT OUTPUT
CTO CIPHER TEXT OUTPUT
CTI CIPHER TEXT INPUT
T/R TRANSMIT (BAR)/RECEIVE
STD STANDARD
INDICATES INTERCONNECT (I) POINT TO MAIN RADIO BOARD
INDICATES DVP RECEIVE PATH
INDICATES DVP TRANSMIT PATH
INDICATES SIGNAL CONTROL
MODU-FLEX CONNECTION
REFERS TO OSCILLOSCOPE WAVEFORM PATTERNS IN APPLICABLE SERVICE MANUAL

V. UNIT IDENTIFICATION

Servicing the microprocessor based Emergency/Unit Identification circuitry is covered in this section. It is recommended that the technician be familiar with Emergency/Unit Identification theory before beginning this section. A complete theory of operation can be found in Service Manual Number 68P81030C65.

Two methods of troubleshooting will be presented: Board level troubleshooting and component level troubleshooting. Where low repair cost is the most important factor, the component level troubleshooting method should be used. On the other hand, if down time of a unit is the most important factor, then the board level troubleshooting method should be used. The technician should choose the method most applicable to his/her needs. But before using either method, replace the code plug (U2) with a known good working part. Because this is a plug-in part and easily removed, it should be the first component isolated on the Emergency/Unit Identification circuitry.

NOTE: If the code plug is missing or is not programmed, two very long, low frequency tones, lasting several seconds, will be heard at the speaker when the PTT switch is depressed.

Board Level Troubleshooting - In board level troubleshooting, emphasis is placed on determining which of three boards is defective (computer board, interface board, or mother board).

Begin by replacing both the interface and the computer board with known good working boards and key (transmit) the unit. The number displayed on the decoder (if there is no test decoder, arrangements should be made to use the system decoder) should match the number printed on the code plug (U2). If the numbers do not match or the radio fails to operate at all, inspect the mother board and flex circuit for damage and/or cold solder connections. If no defect is found, replace the mother board. If the numbers displayed on the decoder unit and the code plug match each other, take out the interface board, replace it with the original interface board and again transmit to the decoder unit. This time, if the numbers do not match, replacing the interface board is indicated. However, if the numbers match, replace the computer board with the original board and re-transmit to the decoder unit. This time, if the numbers do not match, replacing the computer board should solve the problem. When the faulty board has been replaced, reinsert the original code plug (U2) and again check for proper operation.

UNIT ID TROUBLESHOOTING PROCEDURE CONTINUED

Component Level Troubleshooting - Before attempting this method of troubleshooting, be sure you have read the Theory of Operation in Service Manual Number 68P81030C65. This method will require use of extender boards RTL4124A and RTL4123A.

Begin by removing the interface and computer boards and installing the extender boards in their place. Now reinsert the computer and interface boards into the appropriate extender boards. With boards installed, turn the radio on and perform the standard main transceiver performance checks as listed in TT-403, "Servicing MX300 'Handie-Talkie' Portable Radios". The radio must pass all performance checks to insure proper operation of the Unit Identification circuitry.

When it is determined the radio has a good working main transceiver board, put the radio into transmit mode and begin the following checks.

Start by checking the power supply regulator section (Q10 and Q11). This is accomplished by measuring the DC voltage level at the collector of Q10. It should be approximately 5.2 volts.

When the PTT switch is depressed, the following events take place: Q7 is turned off, Q8 is turned on, and Q6 is turned on.

Use the table below to check for appropriate levels. A high is defined as a DC voltage of greater than 5 volts and a low is defined as a DC voltage of less than 0.5 of a volt. As you go through these checks, should you encounter an incorrect voltage reading on a transistor, use standard transistor troubleshooting techniques to locate the failed component.

	EMITTER	BASE	COLLECTOR
Q7	Low	Low	High
Q8	Low	High	Low
Q6	High	Low	High

Next in the sequence, Q6 is turned on and C4 charges, causing the collector of Q5 to go low for 5 microseconds. This low is applied to U1 at Pin 1 and causes Pin 8 of U1 to go low. This, in turn, causes Q13 to turn on and applies power to U2 (code plug). With power applied, output data from U2 is read into U1 at Pin 25. After the data is read into U1, Q13 is turned off and Pin 10 of U1 goes high, turning Q3 and Q4 on.

In addition to the action described in the preceeding paragraphs, the following events take place when the PTT switch is depressed. Pin 7 of U1 outputs a 989 Hz side tone to the speaker via Q1 and Pin 11 of U1 goes high, muting the microphone. This activity happens only during the ID signaling period.

The final check to make in the unit ID circuitry is to measure the outputs of U1 at the pin numbers called out below. If an incorrect reading is found, check for crystal activity before replacing U1. This check is performed using an RF millivoltmeter at Pin 4 of U1. The oscillator must be running for U1 to function properly. A reading of greater than 1000 millivolts indicates the oscillator is running. If the oscillator is running and an incorrect reading is found, then changing U1 should solve the problem. It is recommended the checks below be made with an oscilloscope.

U1 PIN NUMBER	DC VOLTAGE LEVEL
1	High (pulsed low at key-up)
2	High (pulsed low by emergency switch)
7	High (pulsed high during pre-time)
8	High (pulsed low for 5 microseconds)
10	High (pulsed low at key-up)
11	Low (pulsed high during signaling)
13	Low (pulsed high during signaling)
24	Low (always)
28	High (always Vdd)

VI SELECTIVE CALL

Options H701, Single Address Paging, and H703, Single Address with Group Call Paging, are covered in this section. It is recommended the technician be familiar with selective call theory before beginning to troubleshoot. A complete theory of operation can be found in the MX-300 Series "Handie-Talkie" Theory/Maintenance Manual, P/N 68P81013C70.

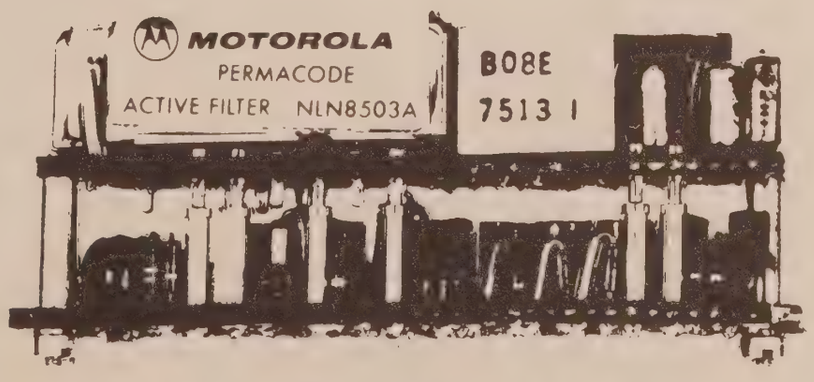
Begin by making a 20 dB quieting check to insure the receiver is operating properly. A receiver having poor sensitivity can cause the SELECTIVE CALL not to operate.

If the radio fails the quieting check, the receiver must be repaired before troubleshooting the SELECTIVE CALL circuitry.

Procedures for making the quieting check as well as procedures for troubleshooting the receiver can be found in Technician's Guide TT-403, Servicing MX-300 "Handie-Talkie" Portable Radios.

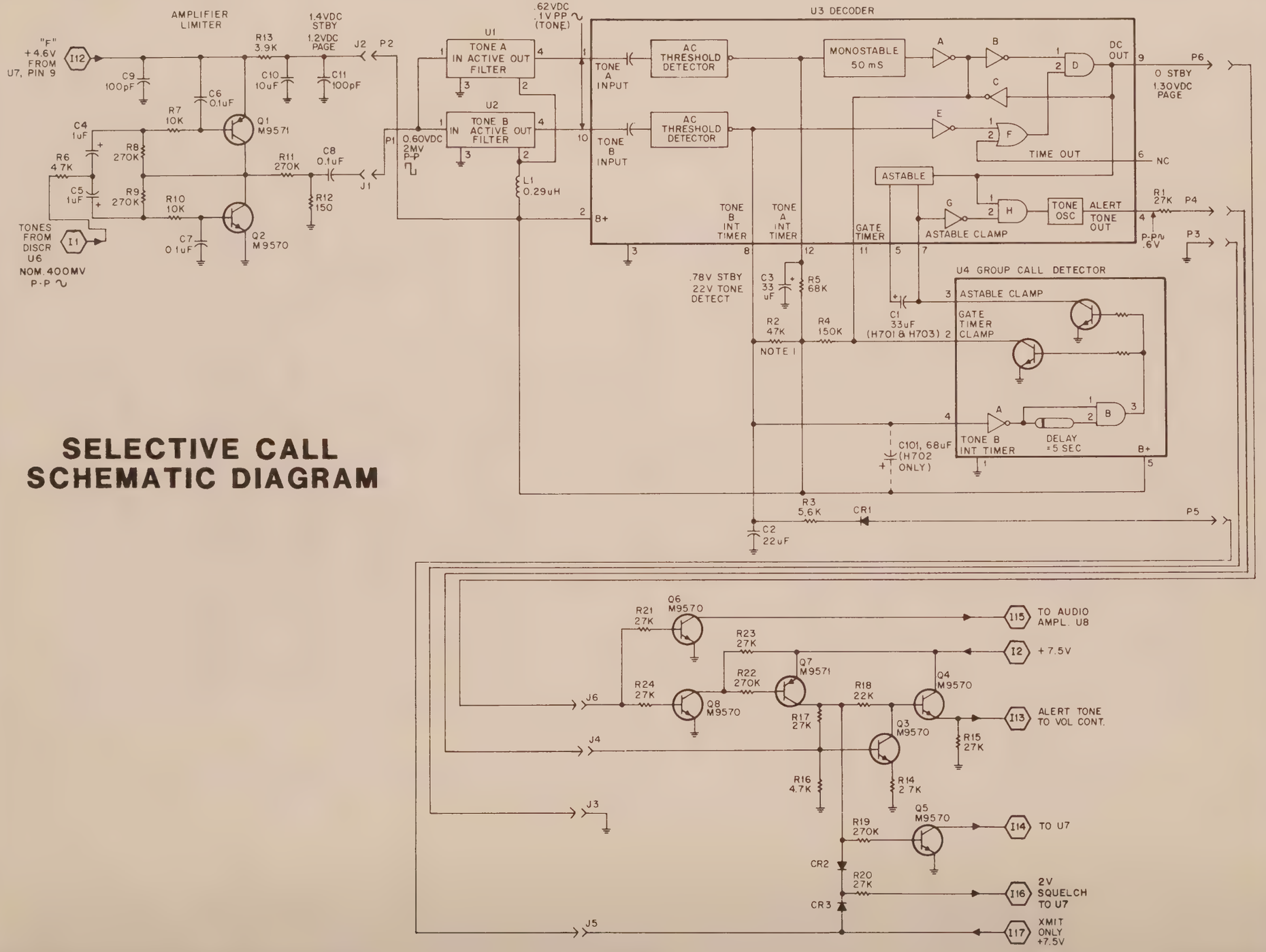
When the receiver is working properly, begin the stage by stage checks as listed on the following page.

SELECTIVE CALL



ASSEMBLED BOARDS

SELECTIVE CALL SCHEMATIC DIAGRAM



VII TIME-OUT-TIMER

This section covers servicing the "Time-Out-Timer" (Option Number H901) for the non-synthesized MX-300 Series Radio.

The Time-Out Timer is mounted on the control flex next to the PTT switch. This location makes it difficult to directly access the pinouts of hybrid module U301; therefore, use only the test points called out in the tables below. For the location of the test points and a schematic diagram of the Time-Out Timer circuitry, refer to the following publications: VHF - P/N 68P81013C71; UHF - P/N 68P81013C75.

Experience has shown that if this option fails to perform as described in the Theory and Maintenance Manual, the problem will generally be either U301 or the timing capacitor C303. The following procedure will assist you in quickly isolating the faulty component.

The Time-Out Timer circuitry is active only during the transmit mode and will limit transmitting time to approximately 30 seconds. At the end of the 30 second timing cycle, the radio will automatically switch from transmit to receive, sending an alert tone to the speaker. (A complete theory of operation can be found in the "MX300" Series Theory/Maintenance Manual, P/N 68P81036C95).

To begin troubleshooting, key the radio and monitor test point one (Pin 1 of U301) with a DC voltmeter. In normal operation, the voltage will vary from 0.0 VDC at initial key-up to greater than 7 VDC at the end of the timing cycle (approximately 30 seconds).

If the voltage at TP1 stays below 7 VDC and does not vary, C303 should be replaced. However, if the voltage measurement indicates normal operation, changing U301 should solve the problem.

If the radio does not operate properly after doing all of the above procedures, use the readings in Tables 1 and 2 below to further isolate the cause.

It should be noted that the readings in Table 1 must be completed within the first 30 seconds of initial key-up. The readings in Table 2 are made only after the unit has timed out (approximately 30 sec).

If your voltage measurements on the control flex do not match the readings shown in the tables, then first inspect the control flex for any damage and repair as necessary. If no damage is found, reflow the solder at the control flex pinouts E1, E2, E9 and E11.

If after doing all of the above tests the Time-Out Timer still fails to operate properly according to the Theory and Maintenance Manual, the Control Flex should be replaced.

INITIAL KEY UP VOLTAGE READINGS

TEST POINT	DC READING
E1	+0.7v
E2	+7.5v
E9	+2 to 4v
E11	+1.2 to 1.8v
TP1	+7v

TABLE 1

VOLTAGE READINGS AFTER TIME OUT

TEST POINT	DC READING
E1	0.0v
E2	+7.5v
E9	0.0v
E11	*25 mv rms
TP1	+7.5v

*Measured with AC voltmeter

TABLE 2

NOTES

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Wherever Motorola sells, our product is backed by service. In the U.S., we have 900 authorized or company-owned stations. In addition, our products are serviced throughout the world by a wide network of company or authorized independent distributor service organizations.

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